Space Weather Technical Forecast

Issued on Sunday, 13 March 2022 at 00:26 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: G1/Minor geomagnetic storms likely with a Chance of G2/Moderate storm on Days 1 and 2 (13-14 Mar). Reducing Chance of further M-Class flares.

Analysis of Space Weather Activity over past 24 hours
Solar Activity: Solar activity has been Low over the past 24 hours, with some low level C-class flares observed. These originated mostly from AR2965 in the northeast and the plage area in the northwest which gave a long period C-flare on 10 March and a large full halo CME, which is Earth directed.
There are currently four numbered sunspot regions on the visible disc, with AR2965 the largest and most magnetically complex. There are also two other reasonably large groups, AR2960 and AR2964, the latter of which is the source of an M2.3 flare late on 11 March. The remaining sunspot on the disc is small and weak.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR at L1, showed waning CME effects early in the period. The wind speed was at background or slightly elevated levels, varying between 380-420 km/s. The density peaked just above average before 12/0600 UTC, before declining to below average levels. The IMF, Bt, was Moderate to start with a maximum of 10nT, but soon eased to weak and is currently steady near 4nT. The north-south component, Bz, reached -9nT early in the period, but is now varying weakly in a mainly southward direction. The phi angle started variable, but became negative (toward the Sun), after 12/0600 UTC. Geomagnetic activity started at G1/Minor Storm (Kp 5) levels, but has since eased to mainly Quiet (Kp1-2).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) measured at GOES 16 returned to background levels after a slight rise in response to a flare on 10 March.
The high energy electron flux (greater than 2 MeV) was at background levels, with the corresponding 24-hour integrated electron fluence well below the Active (1e8 integrated pfu) threshold. Observed fluence at 13/0000 UTC was 1.2e6 integrated pfu.

Four-Day Space Weather Forecast Summary
Solar Activity: Solar activity is expected to be mainly Low, perhaps Moderate, with a chance of M-class flares. The risk of M-flares mainly comes from AR2965 and AR2964, with the risk reducing slightly through Days 2 and 3 (14-15 Mar) as AR2964 rotates off the disc.

Solar Wind / Geomagnetic Activity: There are two potentially Earth-directed CMEs in the forecast. The first is from a filament lift off on 09 March. A marginal influence is possible at Earth either late 13th March or more likely through 14th March. The second is a large full halo CME emitted on the 10th March, and is also expected to arrive either late on 13th March or early on 14th March. Meanwhile, CH65/- in the west may also bring faster winds during Day 1 (13 Mar). Any high speed stream is likely to be masked by the large CME.
Geomagnetic activity is expected to be mostly Quiet to start. Activity is likely to increase with the

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CME arrival(s), becoming Unsettled to G1/Minor Storm (Kp 5), with a Chance of a G2/Moderate Storm (Kp 6). Geomagnetic activity will then gradually return to largely Quiet to Unsettled levels during Days 3 and 4.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain predominantly at background levels, albeit with a very slight chance of rising above the S1 level.
The high energy (greater than 2 MeV) electron flux is currently at background levels. An increase in electron levels is possible but unlikely through Day 1, before a CME arrival late Day 1 or early Day 2 (13-14 Mar) will then further suppress electron levels. As the CME effects wane through Days 3 and 4 (15-16 Mar), then electron flux levels may start to increase.

The corresponding fluence is expected to be below the Active threshold (1e8 integrated pfu) through much of this period, with an increase possible through Days 3 and 4.

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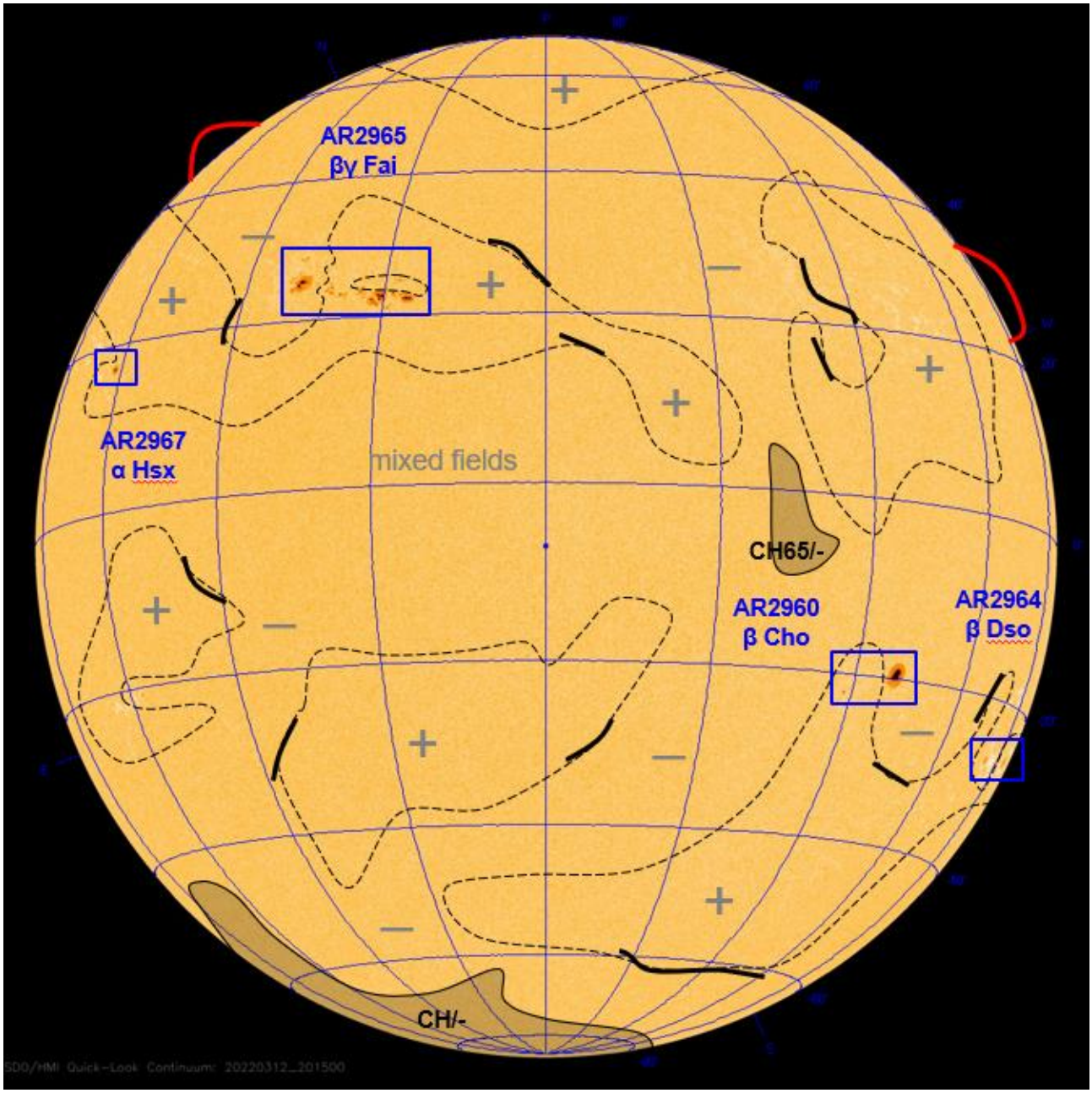
Figure 1. Solar Analysis Valid 12/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are two potentially Earth-directed CMEs in the forecast. The first is from a filament lift off from the southeastern limb late in the UTC evening of 09 March, with the resultant Coronal Mass Ejection (CME) clearly discernible in imagery. A marginal influence is possible at Earth from at least the shock either late 13th March or more likely through 14th March. The second is a large full halo CME emitted on the 10th March, and is also expected to arrive either late on 13th March or early on 14th March, and will probably be a larger impact than the 9th March CME.

Meanwhile, CH65/- in the west may bring faster winds during Day 1 (13 Mar), although this feature is closing up and likely to be weak. In any case, any high speed stream is likely to be masked by the large CME. The combination of the arrival of the two CMEs and the HSS late on Day 1 or early Day 2 (14 Mar) gives an increased risk of Minor to Moderate geomagnetic storms during Days 1 and 2. Effects are likely to slowly wane through Day 3 (15 Mar), with wind speeds returning to background levels during Day 4 (16 Mar).

Geomagnetic activity is expected to be mostly Quiet to start. Activity is likely to increase with the CME arrival(s), becoming Unsettled to G1/Minor Storm (Kp 5), with a Chance of a G2/Moderate Storm (Kp 6). Geomagnetic activity will then gradually return to largely Quiet to Unsettled levels during Days 3 and 4.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	70	70	20	1
Strong	G3	No	5	5	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
09/2300	Partial	SE quadrant filament	36E 18S	445 km/s	13/2300 UTC	Possible shock from glancing blow
11/0406	Full	NW quadrant	Approx 11W 23N	577	13/2200 UTC (+/-6 hours)	Earth directed

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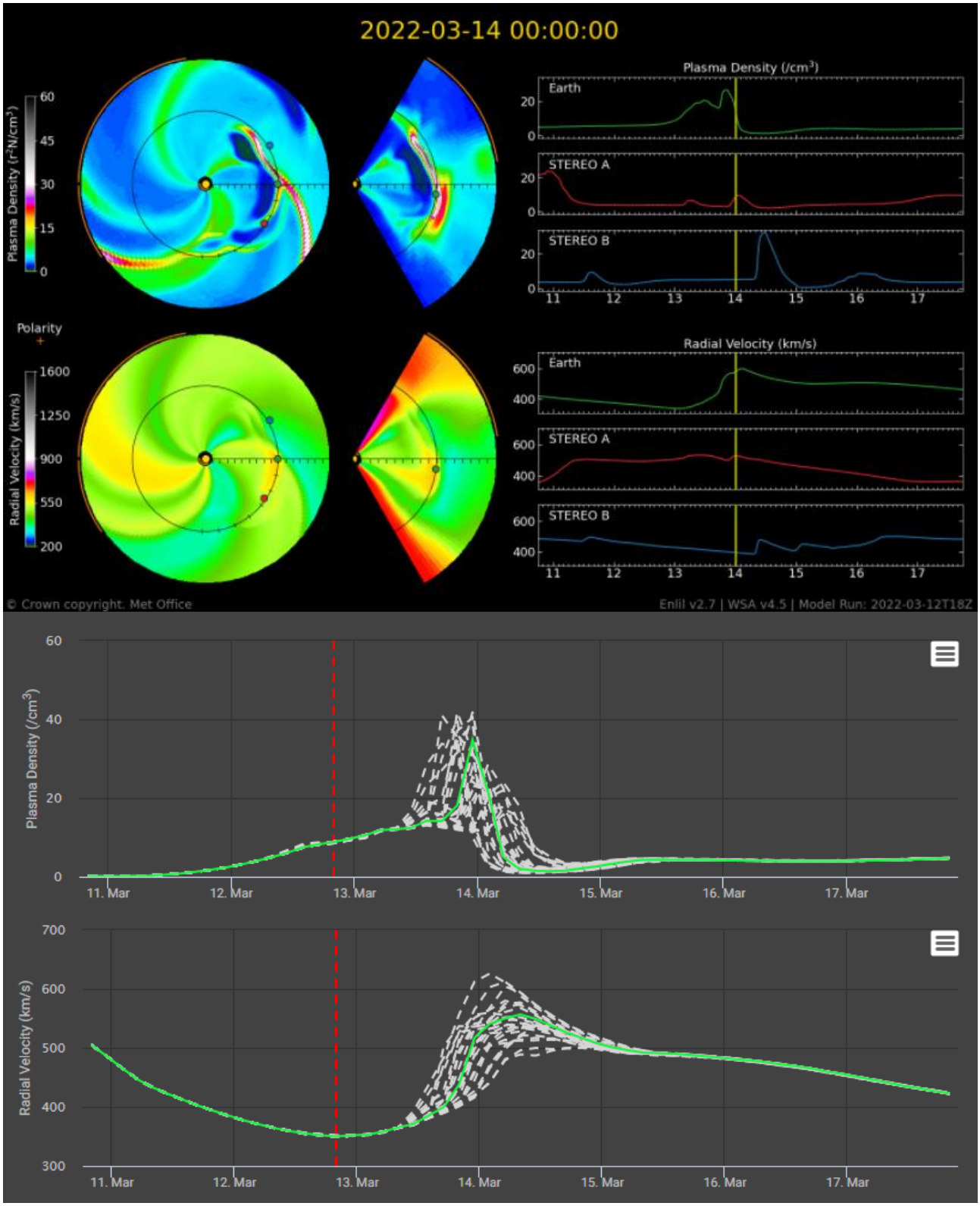
Figure 2: Enlil model and ensemble, showing likely arrival of an Earth directed CME late on 13 March or early on 14 March.



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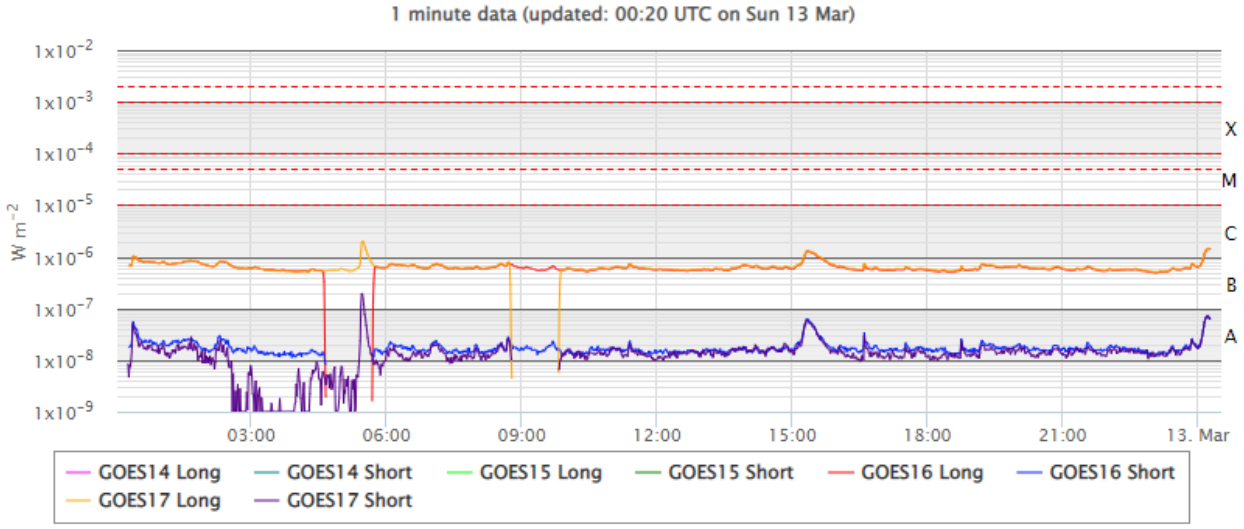
Radio Blackouts - X-Ray Flares:
There are currently four sunspot regions on the visible disc. AR2964 (Dso/Beta) in the southwest is now hard to classify as it approaches the western limb. This region emitted an M-class flare late on the 11th and is likely to give a continued but declining risk through Days 2 and 3 (14-15 Mar) as it rotates off the disc. AR2966 was just ahead of 2964 and is now no longer visible.
AR2965 (Fai/Beta-Gamma) in the northwest is by far the largest and also most complex region, but has only produced C-class flares. This region will be closely monitored and is partly responsible for the elevated M-class flare risk in the forecast above.
AR2960 (Cho/Beta) is continuing to simplify, remaining a large but stable region. AR2967 has rotated onto the northeast limb, and is currently a simple Hsx/Alpha region.
The risk of M-class flares reduces through Days 2 and 3 (14-15 Mar) as AR2964 rotates off the visible disc and beyond the western limb.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	30	25	20	20
Very Active	R3 to R5 X Class	No	2	2	2	2

Figure 3: X-ray flares in the last 24 hours, with only minor C-class flares.



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Solar Radiation Storms - (High Energy Protons):
The high energy proton flux (10MeV) measured at GOES 16 has returned to background levels after a slight rise due to the long period C-class flare from a plage region in the northwest on 10 March.
There is just a very slight chance of an S1/Minor radiation storm, should any further flares occur from this plage region, or from any of the larger regions on the disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	3	3	3	3
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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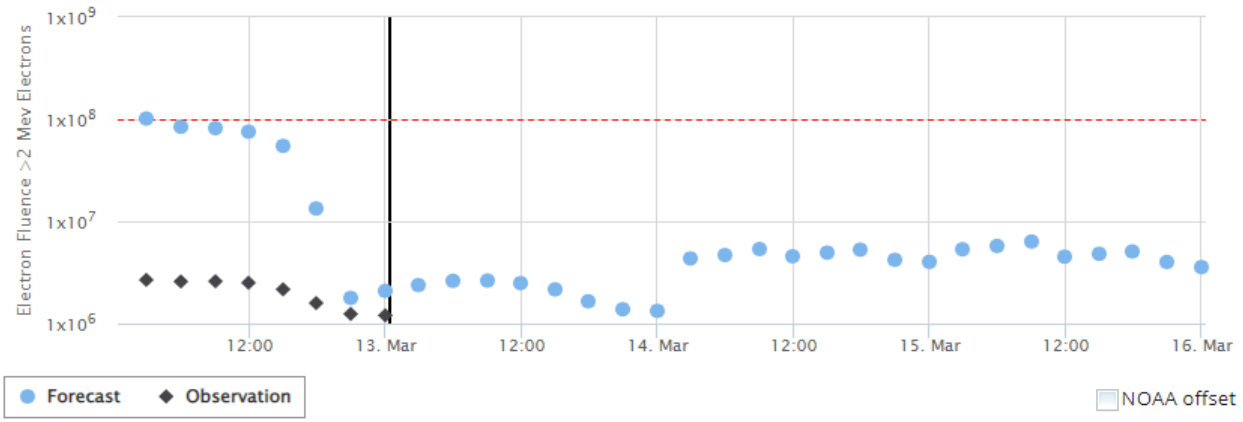
High Energy Electrons Event (≥ 2MeV):
The high energy (greater than 2 MeV) electron flux is currently at background levels, after being suppressed due to recent CME arrivals. A further CME arrival is expected late on Day 1 or early on Day 2 (13-14 Mar). So whilst an increase in electron levels is possible but unlikely through Day 1, the CME arrival will then suppress electron levels once again. Some charging from the higher wind speeds of the CME is possible however, and as the CME effects wane through Days 3 and 4 (15-16 Mar), then electron flux levels may start to increase.

The corresponding fluence is expected to be below the Active threshold (1e8 integrated pfu) through much of this period, with an increase possible through Days 3 and 4.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	5	1	10	30
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 4: REFM model showing fluence staying below Active threshold. However, REFM does not have information about upcoming CME arrivals and as such is unlikely to give good guidance at this time.



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